AMENDMENTS TO THE DRAWINGS

The attached Replacement Sheet includes changes to Fig. 1. This sheet, which includes only Fig. 1, replaces the original sheet including Fig. 1. Changes incorporated in the Replacement Sheet are highlighted on the attached Annotated Sheet.

Attachment: Replacement Sheet
Annotated Sheet Showing Change.

REMARKS

The drawings stand objected to for failing to clearly indicate which part of the device constitutes "detection fields" and "the flow-through measurement chamber" as described in the specification. In response to this objection, Fig. 1 has been amended to clearly indicate these parts of the device. The Examiner's approval of the amendments to Fig. 1 is requested.

Claim 17 stands objected to for lacking the term "comprising" and claims 17-30 stand rejected under 35 U.S.C. § 112, second paragraph, for indefiniteness. In response to this objection and rejection, claims 17-30 have been amended as set forth above and new claims 31-36 added. It is believed that the amendments to claims 17-30 overcome the objection to claim 17 and the rejection of claims 17-30 under 35 U.S.C. § 112, second paragraph.

Claims 17, 19-22, 27, 28 and 30 stand rejected under 35 U.S.C. § 102(b) for anticipation by U.S. Patent No. 6,287,874 to Hefti. Claims 18, 23, 24 and 26 stand rejected under 35 U.S.C. § 103(a) for obviousness from the teachings of the Hefti patent in view of U.S. Patent Application Publication No. U.S. 2002/0135780 to Budach et al. Claim 25 stands rejected under 35 U.S.C. § 103(a) for obviousness from the teachings of the Hefi patent in view of the Budach et al. publication and further in view of International Application Publication No. WO 97/06422 to FCI-Fiberchem, Inc. Lastly, claim 29 stands rejected under 35 U.S.C. § 103(a) for obviousness from the teachings of the Hefti patent in view of the Budach et al. publication and the FCI-Fiberchem, Inc. publication and further in view of U.S. Patent No. 6,126,899 to Woudenberg et al.

Regarding the rejection under 35 U.S.C. § 102(b), it is settled law that "[a] claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Brothers Inc. v. Union Oil Co. of California, 2 USPQ2d, 1051, 1053 (Fed. Cir. 1987).

Fig. 1a of the Hefti patent discloses a measurement device that includes signal source 110, transmission lines 120, a source/detector ground plane 130, a bio-assay device 150, and a signal detector 160 (see column 12, lines 30-32). The transmission lines 120 are formed from a material which can support the propagation of a signal over the desired frequency of operation. More specifically, each transmission line 120 is realized as a conductive layer, such as gold, deposited on a substrate, such as alumina, diamond, sapphire, polyimide or glass, using conventional photolithography or semiconductor processing techniques (see column 12, lines 38-44). The signal source produces a high-frequency test signal with a frequency between 1 MHz and 1000 GHz 10^6-10^{12} Hz (see column 25, lines 36-43). The Hefti patent, however, does not disclose, teach or suggest an optical waveguide. Specifically, optical

waveguides are transparent for optical radiation with a frequency between approximately 10^{13} Hz and 10^{16} Hz (see enclosed printout from Wikipedia, page 3). Gold and the other conductive layers disclosed in the Hefti patent are simply not transparent for optical radiation.

Moreover, in connection with Fig. 15c of the Hefti patent, column 42, lines 48-63 of the Hefti patent disclose that a light produced by LED 1725 activates FET 1720 to switch out the MBR 1724. However, there is no disclosure, teaching or suggestion in the Hefti patent of producing optical radiation which is suitable for being used for exciting the emission of luminance radiation, as specifically required by the limitations of claim 17.

Lastly, it is not clear from the sections of the Hefti patent cited by the Examiner in the Office Action that the Hefti patent discloses a device where a radiation receiver is associated with a detection field is integrated into the semiconductor substrate facing the detection fields directly on the back side of the waveguide facing away from the detection field.

The other prior art of record does not cure the foregoing deficiencies in the teachings of the Hefti patent.

Absent disclosing, teaching or suggesting a device having all of the limitations of claim 17, the Hefti patent, either individually or in combination with any one or combination of the other prior art of record, cannot anticipate or render obvious claim 17 of the present application, or claims 18-36 dependent therefrom.

Regarding the rejection of claims 18, 23, 24 and 26 under 35 U.S.C. § 103 for obviousness from the teachings of the Hefti patent in view of the Budach et al. publication, reconsideration is requested.

The Budach et al. publication discloses an optical waveguide 32 on the top surface of a glass substrate which has a plurality of grooves 31 etched therein (see page 7, paragraph 0109). The resonance condition described in the Budach et al. publication can be achieved only when grooves 31 of glass substrate 30 and grooves 33 of waveguide 32 have a particular depth (see page 7, paragraph 0111).

It is respectfully submitted that it would not have been obvious to a person skilled in the art to modify the Hefti patent, which discloses high frequency circuitry, with the teachings of the Budach et al. publication, which discloses an optical waveguide. Moreover, it is respectfully submitted that a person skilled in the art would not modify the teachings of the Hefti patent with the teachings of the Budach et al. publication to form a waveguide monolithically integrated with the semiconductor substrate which also contains integrated radiation receivers. To this end, such a semiconductor substrate has a surface topology which is completely different than the grooves 31 of the glass substrate

30 shown in Fig. 2 of the Budach et al. publication. To this end, if the waveguide disclosed in the Budach et al. publication were monolithically integrated with a semiconductor substrate, the resonance condition disclosed in the Budach et al. publication would not be achieved.

Accordingly, it is submitted that it cannot be obvious to combine the teachings of the Hefti patent and the Budach et al. publication in the manner suggested by the Examiner in the Office Action to render obvious claims 18, 23, 24 and 26, or claims 31, 33, 34 and 35 dependent therefrom.

CONCLUSION

Based on the foregoing amendments and remarks, reconsideration of the objections and rejections and allowance of claims 17-36 are requested.

Respectfully submitted,

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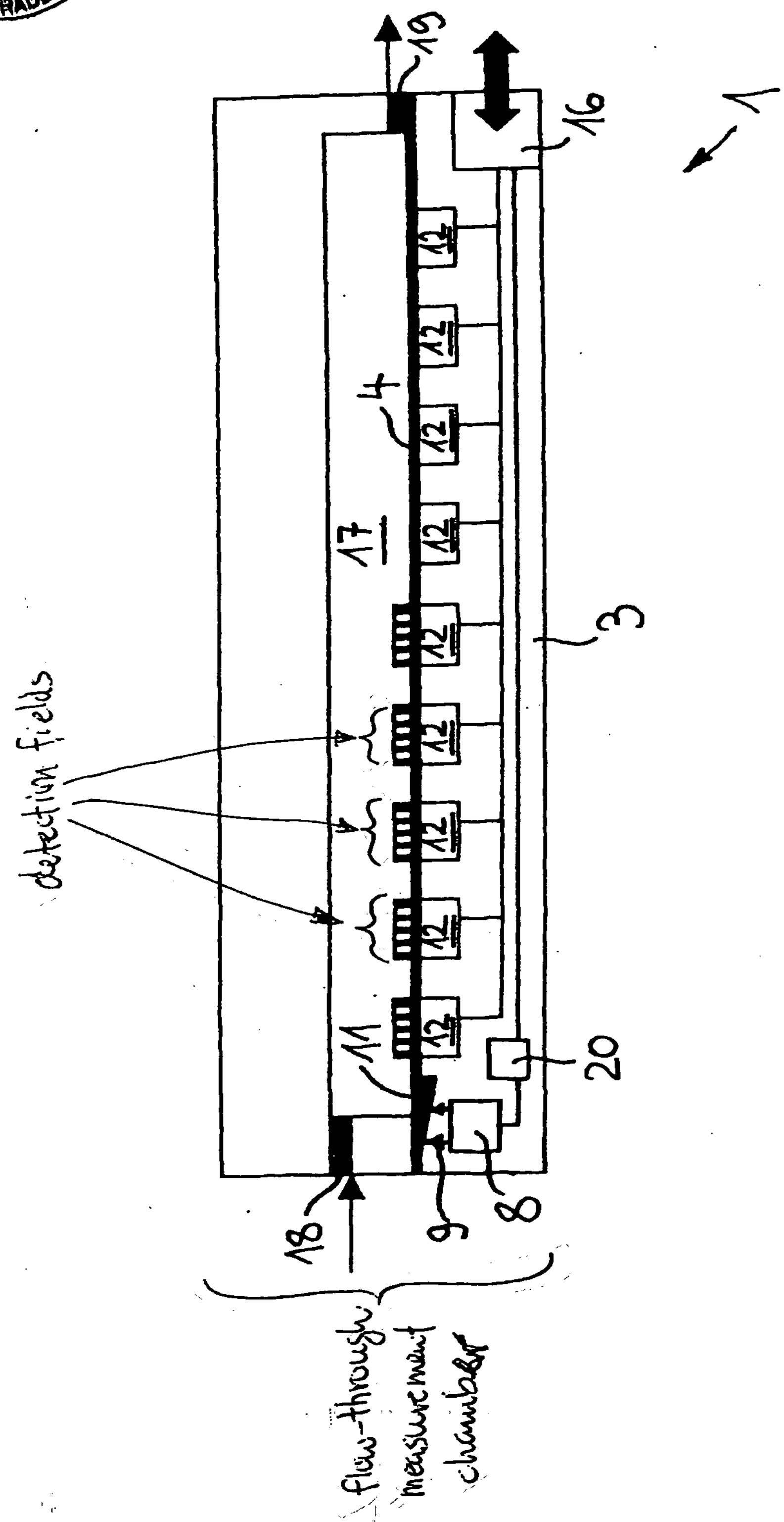
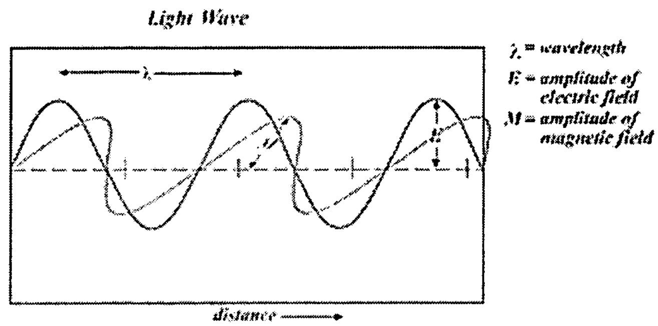


Fig. 1

Electromagnetic radiation

From Wikipedia, the free encyclopedia

Electromagnetic radiation, sometimes informally called **light**, is generally described as a self-propagating wave in space with electric and magnetic components. These components oscillate at right angles to each other and to the direction of propagation, and are in phase with each other.



Electromagnetic radiation can be conceptualized as a self propagating transverse oscillating wave of electric and magnetic fields. This diagram shows a plane linearly polarised wave propagating from left to right.

Electromagnetic (EM) radiation carries energy and momentum, which may be imparted when it interacts with matter.

Contents

Physics

Theory

Electromagnetic waves of much lower frequency than visible light were first predicted by Maxwell's equations and subsequently discovered by Heinrich Hertz. Maxwell derived a wave form of the electric and magnetic equations, revealing the wavelike nature of electric and magnetic fields and their symmetry. Energy comes in the form of electromagnetic radiation which are emitted in waves. The equation lambda x v(nv) = speed of light) relates the three parts of electromagnetic radiation.

According to these equations, a time-varying electric field generates a magnetic field and *vice versa*. Therefore, as an oscillating electric field generates an oscillating magnetic field, the magnetic field in turn generates an oscillating electric field, and so on. These oscillating fields together form an electromagnetic wave.

Properties

Electric and magnetic fields obey the properties of superposition, so fields due to particular particles or time-

varying electric or magnetic fields contribute to the fields due to other causes. (As these fields are vector fields, all magnetic and electric field vectors add together according to vector addition.) These properties cause various phenomena including refraction and diffraction. For instance, a travelling EM wave incident on an atomic structure induces oscillation in the atoms, thereby causing them to emit their own EM waves. These emissions then alter the impinging wave through interference.

Since light is an oscillation, it is not affected by travelling through static electric or magnetic fields in a linear medium such as a vacuum. In nonlinear media such as some crystals, however, interactions can occur between light and static electric and magnetic fields - these interactions include the Faraday effect and the Kerr effect.

In refraction, a wave crossing from one medium to another of different density alters its speed and direction upon entering the new medium. The ratio of the refractive indices of the media determines the degree of refraction, summarized by Snell's law. Light disperses into a visible spectrum as light is shone through a prism because of refraction.

The physics of electromagnetic radiation is electrodynamics, a subfield of electromagnetism.

EM radiation exhibits both wave properties and particle properties at the same time (see wave-particle duality). However, these characteristics are mutually exclusive and appear separately in different circumstances: the wave characteristics appear when EM radiation is measured over relatively large timescales and over large distances, and the particle characteristics are evident when measuring small distances and timescales. Both characteristics have been confirmed in a large number of experiments.

Wave model

An important aspect of the nature of light is frequency. The frequency of a wave is its rate of oscillation and is measured in hertz, the SI unit of frequency, equal to one oscillation per second. Light usually has a spectrum of frequencies which sum together to form the resultant wave. Different frequencies undergo different angles of refraction.

A wave consists of successive troughs and crests, and the distance between two adjacent crests is called the wavelength. Waves of the electromagnetic spectrum vary in size, from very long radio waves the size of buildings to very short gamma rays smaller than atom nuclei. Frequency is the inverse of wavelength. As waves cross boundaries between different media, their speed changes but their frequency remains constant.

Interference is the superposition of two or more waves resulting in a new wave pattern. If the fields have components in the same direction, they constructively interfere, while opposite directions cause destructive interference.

The energy in electromagnetic waves is sometimes called radiant energy.

Particle model

In the particle model of EM radiation, a wave consists of discrete packets of energy, or quanta, called photons. The frequency of the wave is proportional to the magnitude of the particle's energy. Moreover, because photons are emitted and absorbed by charged particles, they act as transporters of energy.

As a photon is absorbed by an atom, it excites an electron, elevating it to a higher energy level. If the energy is great enough, so that the electron jumps to a high enough energy level, it may escape the positive pull of the nucleus and be liberated from the atom in a process called ionization. Conversely, an electron that descends to a lower energy level in an atom emits a photon of light equal to the energy difference. Since the energy levels of

electrons in atoms are discrete, each element emits and absorbs its own characteristic frequencies.

Together, these effects explain the absorption spectra of light. The dark bands in the spectrum are due to the atoms in the intervening medium absorbing different frequencies of the light. The composition of the medium through which the light travels determines the nature of the absorption spectrum. For instance, dark bands in the light emitted by a distant star are due to the atoms in the star's atmosphere. These bands correspond to the allowed energy levels in the atoms. A similar phenomenon occurs for emission. As the electrons descend to lower energy levels, a spectrum is emitted that represents the jumps between the energy levels of the electrons. This is manifested in the emission spectrum of nebulae. Today, scientists use this phenomenon to observe what elements a certain star is composed of. It is also used in the determination of the distance of a star, using the so-called red shift.

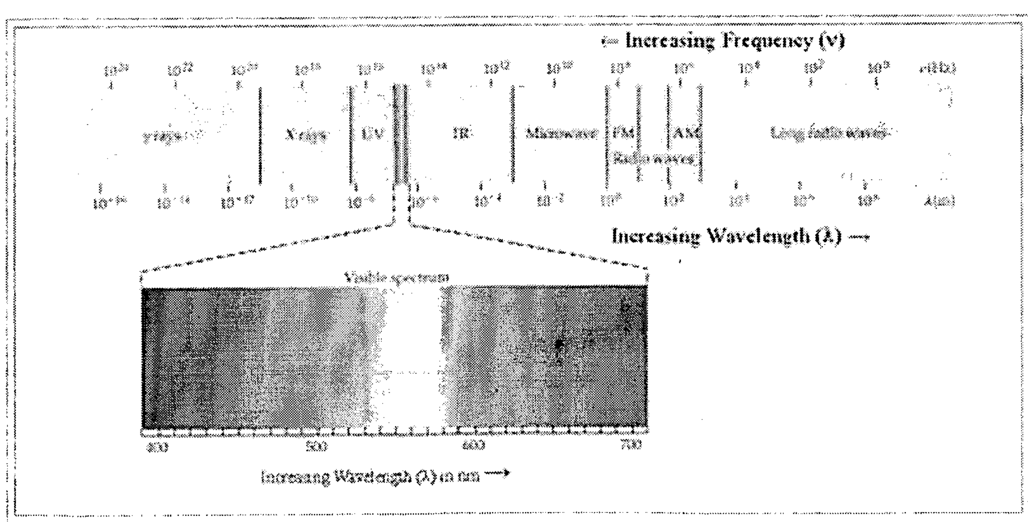
Speed of propagation

Any electric charge which accelerates, or any changing magnetic field, produces electromagnetic radiation. Electromagnetic information about the charge travels at the speed of light. Accurate treatment thus incorporates a concept known as retarded time (as opposed to advanced time, which is unphysical in light of causality), which adds to the expressions for the electrodynamic electric field and magnetic field. These extra terms are responsible for electromagnetic radiation. When any wire (or other conducting object such as an antenna) conducts alternating current, electromagnetic radiation is propagated at the same frequency as the electric current. Depending on the circumstances, it may behave as a wave or as particles. As a wave, it is characterized by a velocity (the speed of light), wavelength, and frequency. When considered as particles, they are known as photons, and each has an energy related to the frequency of the wave given by Planck's relation $E = h\nu$, where E is the energy of the photon, $h = 6.626 \times 10^{-34}$ J·s is Planck's constant, and ν is the frequency of the wave.

One rule is always obeyed regardless of the circumstances: EM radiation in a vacuum always travels at the speed of light, *relative to the observer*, regardless of the observer's velocity. (This observation led to Albert Einstein's development of the theory of special relativity.)

In a medium (other than vacuum), velocity of propagation or refractive index are considered, depending on frequency and application. Both of these are ratios of the speed in a medium to speed in a vacuum.

Electromagnetic spectrum



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Electrom:

Legend:
γ = Gamma rays
HX = Hard X-rays
SX = Soft X-Rays
EUV = Extreme ultraviolet
NUV = Near ultraviolet
Visible light
NIR = Near infrared
MIR = Moderate infrared
FIR = Far infrared

Radio waves:
EHF = Extremely high frequency (Microwaves)
SHF = Super high frequency (Microwaves)
UHF = Ultrahigh frequency
VHF = Very high frequency
HF = High frequency
MF = Medium frequency
LF = Low frequency
VLF = Very low frequency
VF = Voice frequency
ELF = Extremely low frequency

CLASS	FREQUENCY	WAVELENGTH	ENERGY
γ	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
	3 EHz	100 pm	12.4 keV
SX	300 PHz	1 nm	1.24 keV
	30 PHz	10 nm	124 eV
EUV	3 PHz	100 nm	12.4 eV
NUV			
NIR	300 THz	1 μm	1.24 eV
MIR	30 THz	10 μm	124 meV
FIR	3 THz	100 μm	12.4 meV
EHF	300 GHz	1 mm	1.24 meV
SHF	30 GHz	1 cm	124 μeV
UHF	3 GHz	1 dm	12.4 μeV
VHF	300 MHz	1 m	1.24 μeV
HF	30 MHz	1 dam	124 neV
MF	3 MHz	1 hm	12.4 neV
LF	300 kHz	1 km	1.24 neV
VLF	30 kHz	10 km	124 peV
VF	3 kHz	100 km	12.4 peV
ELF	300 Hz	1 Mm	1.24 peV
	30 Hz	10 Mm	124 feV

Generally, EM radiation is classified by wavelength into e... rical energy, radio, microwave, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays.

The behavior of EM radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths. When EM radiation interacts with single atoms and molecules, its behavior depends on the amount of energy per quantum it carries.

Spectroscopy can detect a much wider region of the EM spectrum than the visible range of 400 nm to 700 nm. A common laboratory spectroscope can detect wavelengths from 2 nm to 2500 nm. Detailed information about the physical properties of objects, gases, or even stars can be obtained from this type of device. It is widely used in astrophysics. For example, many hydrogen atoms emit radio waves which have a wavelength of 21.12 cm.

Light

EM radiation with a wavelength between approximately 400 nm and 700 nm is detected by the human eye and perceived as visible light.

If radiation having a frequency in the visible region of the EM spectrum reflects off of an object, say, a bowl of fruit, and then strikes our eyes, this results in our visual perception of the scene. Our brain's visual system processes the multitude of reflected frequencies into different shades and hues, and through this not-entirely-understood psychophysical phenomenon, most people perceive a bowl of fruit.

In the vast majority of cases, however, the information carried by light is not directly detected by human senses. Natural sources produce EM radiation across the spectrum, and our technology can also manipulate a broad range of wavelengths. Optical fiber transmits light which, although not suitable for direct viewing, can carry data that can be translated into sound or an image. The coding used in such data is similar to that used with radio waves.

Radio waves

Radio waves carry information by varying a combination of the amplitude, frequency and phase of the wave within a frequency band.

When EM radiation impinges upon a conductor, it couples to the conductor, travels along it, and induces an electric current on the surface of that conductor by exciting the electrons of the conducting material. This effect (the skin effect) is used in antennas. EM radiation may also cause certain molecules to absorb energy and thus to heat up; this is exploited in microwave ovens.

Derivation

Electromagnetic waves as a general phenomenon were predicted by the classical laws of electricity and magnetism, known as Maxwell's equations. If you inspect Maxwell's equations without sources (charges or currents) then you will find that, along with the possibility of nothing happening, the theory will also admit nontrivial solutions of changing electric and magnetic fields. (For symbol definitions see magnetic field.)

$$\nabla \cdot \mathbf{E} = 0$$
$$\nabla \times \mathbf{E} = -\frac{\partial}{\partial t}\mathbf{B}$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial}{\partial t}\mathbf{E}$$

$\mathbf{E} = \mathbf{B} = 0$ is a solution, but there might be other solutions as well. Let us employ a useful identity from vector calculus.

$$\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A}$$

Where $\mathbf{A}$ can be any vector function. Taking the curl of the curl equations and applying the identity, we get the following.

$$\nabla^2 \mathbf{E} = \mu_0 \epsilon_0 \frac{\partial^2}{\partial t^2}\mathbf{E}$$
$$\nabla^2 \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial^2}{\partial t^2}\mathbf{B}$$

These types of equations are identified as linear wave equations with wave speed $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$, which was found to be equal to the speed of light. Maxwell's equations have unified the permittivity of free space ε_0, the permeability of free space μ_0, and the speed of light itself: $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$. Before this derivation it was not known that there was such a strong relationship between light and electricity and magnetism.

But these are only two equations and we started with four, so there is still more information pertaining to these

waves hidden within Maxwell's equations. Let's consider a generic vector wave for the electric field.

$$\mathbf{E} = \mathbf{E}_0 f\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right)$$

Here $\mathbf{E}_0$ is the constant amplitude, f is any second differentiable function, $\hat{\mathbf{k}}$ is a unit vector in the direction of propagation, and $\mathbf{x}$ is a position vector. We observe that $f\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right)$ is a generic solution to the wave equation. In other words

$$\nabla^2 f\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right) = \frac{1}{c^2}\frac{\partial^2}{\partial^2 t} f\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right),$$

for a generic wave traveling in the $\hat{\mathbf{k}}$ direction. The proof of this is trivial.

This form will satisfy the wave equation, but will it satisfy all of Maxwell's equations, and with what corresponding magnetic field?

$$\nabla \cdot \mathbf{E} = \hat{\mathbf{k}} \cdot \mathbf{E}_0 f'\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right) = 0$$

$$\mathbf{E} \cdot \hat{\mathbf{k}} = 0$$

The first of Maxwell's equations implies that electric field is orthogonal to the direction the wave propagates.

$$\nabla \times \mathbf{E} = \hat{\mathbf{k}} \times \mathbf{E}_0 f'\left(\hat{\mathbf{k}} \cdot \mathbf{x} - ct\right) = -\frac{\partial}{\partial t}\mathbf{B}$$

$$\mathbf{B} = \frac{1}{c}\hat{\mathbf{k}} \times \mathbf{E}$$

The second of Maxwell's equations yields the magnetic field. The remaining equations will be satisfied by this choice of $\mathbf{E}, \mathbf{B}$.

Not only are the electric and magnetic field waves traveling at the speed of light, but they have a special restricted orientation and proportional magnitudes, $E_0 = cB_0$. The electric field, magnetic field, and direction of wave propagation are all orthogonal and the wave propagates in the same direction as $\mathbf{E} \times \mathbf{B}$.

From the viewpoint of an electromagnetic wave traveling forward, the electric field might be oscillating up and down, while the magnetic field oscillates right and left; but this picture can be rotated with the electric field oscillating right and left and the magnetic field oscillating down and up. This is a different solution that is traveling in the same direction. This arbitrariness in the orientation with respect to propagation direction is known as polarization.

See also

- Electromagnetic wave equation
- Electromagnetic spectrum
- Electromagnetic radiation hazards

- Radiant energy
- Light
- Light frequency waves
- Electromagnetic pulse
- Control of electromagnetic radiation
- Klystron
- Helicon

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External links

General

- Conversion of frequency to wavelength and back - electromagnetic, radio and sound waves (http://www.sengpielaudio.com/calculator-wavelength.htm)
- The Science of Spectroscopy (http://www.scienceofspectroscopy.info/) - supported by NASA. Spectroscopy education wiki and films - introduction to light, its uses in NASA, space science, astronomy, medicine & health, environmental research, and consumer products.

Patents

- Greenleaf Whittier Pickard - U.S. Patent 876996 (http://patft.uspto.gov/netacgi/nph-Parser?patentnumber=876996) - *Intelligence intercommunication by magnetic wave component*

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Category: Electromagnetic radiation

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